AD-A075 723 NAVAL RESEARCH LAB WASHINGTON DC F/G 17/2.1
CONSIDERATIONS FOR THE SELECTION OF MILLIMETER FREQUENCY BANDS --ETC(U)
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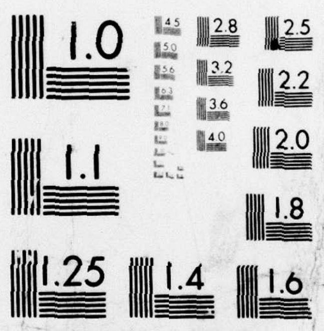


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(10) David H. /Townsend

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(9) TECHNICAL MEMORANDUM

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SUBJECT: (6) Considerations for the Selection of Millimeter Frequency ~~Bands~~ Bands for Mobile Satellite Communications.



1. To provide communications for Naval forces at sea, a communications system must be mobile and must provide ocean coverage. At line-of-sight frequencies, the necessary coverage is provided by satellite relay. For practical and military reasons, mobile SATCOM terminals for the Navy must be limited in size, weight, and cost and must provide substantial resistance to jamming or unintentional interference along with a low probability that transmissions will be intercepted. It is primarily the military requirement for anti-jam (AJ) and low probability of intercept (LPI) performance in Naval SATCOM systems that dictates a need for millimeter wavelength systems where wide bandwidth transmissions for AJ/LPI and narrow antenna beamwidths for LPI are possible along with the size and weight necessary in mobile terminals (fig. 1).

2. If, within the limits of technology, it is assumed that the only frequency dependent parameters in a link power budget for a SATCOM system are the uplink and downlink gains of the terminals and the uplink and downlink free space losses to a satellite having fixed area coverage, then the data throughput capacity of a SATCOM system is constant with respect to frequency. The above statement intentionally ignores propagation effects such as scintillation and absorption but serves to illustrate that for large portions of the millimeter wave band communications capacity equal to that achievable at more conventional microwave frequencies is possible (fig. 2). Except for those frequencies where propagation effects dominate performance, the potential at millimeter wavelengths is very great for non-interfering wide bandwidth transmissions for AJ/LPI performance and narrow beamwidth antennas with low sidelobe levels for LPI performance.



3. System complexities and, consequently, system costs can be minimized in the millimeter wavelength bands. The separation between uplink and downlink frequencies at millimeter wavelengths permits transmit/receive diplexers to be built which have high isolation at low cost. By comparison, the 7/8 GHz SATCOM bands are separated by less than 2 percent bandwidth while requiring in excess of 120 decibels isolation in the diplexer between transmit and receive ports. Adjacent band interference and intermodulation problems can be more easily handled by the large frequency separation at millimeter wavelengths between up and down links.

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4. Lightweight miniature components are available at millimeter wavelengths. Weight is a crucial factor for mobile SATCOM terminals when combined with the desire for low cost systems. If the cost of mobile SATCOM terminals is to be kept low while requiring nearly unobstructed hemispheric coverage, a single antenna system is desired over a dual antenna system. On crowded vessels to have a single antenna installation with unobstructed coverage requires the antenna to be mast mounted. Mast mounting, in turn, requires lightweight terminals. Frequency scaling of components reduces their dimensions in proportion to the reduction in wavelength. Therefore, millimeter wave RF components can be significantly reduced in size and weight as compaired to similar components at lower frequencies.

5. Since Naval operations are concentrated on the ocean areas of the world, satellite antenna "footprints" on the earth can be tailored to provide coverage for mobile Naval forces and shore stations without illuminating large areas of land where communications are not needed. Two benefits which derive from such "tailored footprints" are the reduction of interference by the satellite to terrestrial systems and the reduction of interference by terrestrial systems including land based jammers to satellite communications. Millimeter wavelengths permit satellite apertures with dimensions many wavelengths across thereby allowing antennas which are designed for "tailored footprints" to be of reasonable overall size.

6. Nine millimeter wavelength bands have been examined for use with Navy mobile SATCOM systems. These bands are 19.7 - 21.2 GHz, 29.5 - 31 GHz, 36 - 40 GHz, 40 - 41 GHz, 43 - 45 GHz, 50 - 51 GHz, 59 - 64 GHz, 71 - 84 GHz, and 92 - 95 GHz. Because of strong absorption effects in the region of the 60 GHz oxygen resonance line, mobile SATCOM systems operating in the 59 - 64 GHz are restricted to those mobile operations which are conducted outside the earth's atmosphere. Because of the characteristics mentioned earlier and because of the availability of components up to 40 GHz, mobile SATCOM operation in the 19.7 - 21.2 GHz, 29.5 - 31 GHz, 36 - 40 GHz, and 40 - 41 GHz bands is highly desirable. In the 43 - 45 GHz, 50 - 51 GHz, 71 - 84 GHz, and 92 - 95 GHz bands, communications performance is reduced due to absorption effects, but some very desirable AJ/LPI characteristics are derived because transmissions at low angles are absorbed more strongly than at high elevation angles thereby restricting satellite access to high elevation angles (fig. 3). Consequently, all of the nine bands considered are recommended for mobile SATCOM systems. Furthermore, in those bands not already designated for earth-to-space or space-to-earth operation with fixed SATCOM terminals, omitting the reference to uplink and downlink operation is recommended so as to allow greater flexibility in the design of SATCOM systems.

DAVID H. TOWNSEND

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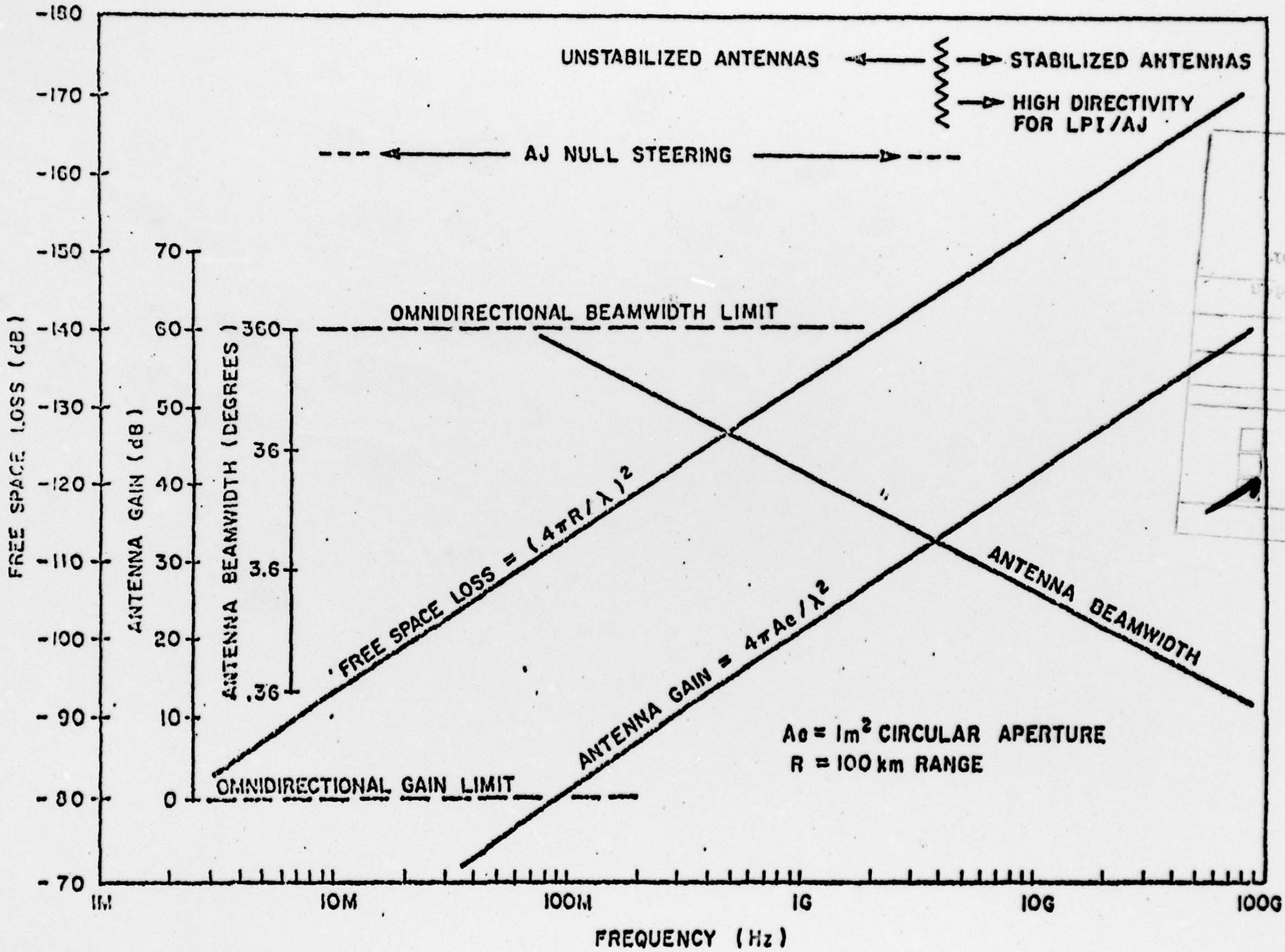


Figure 1. Frequency Dependence of Antenna Parameters

Figure 2. Frequency Dependence of a Hard Limiting SATCOM System for Constant Earth Terminal Aperture Area.

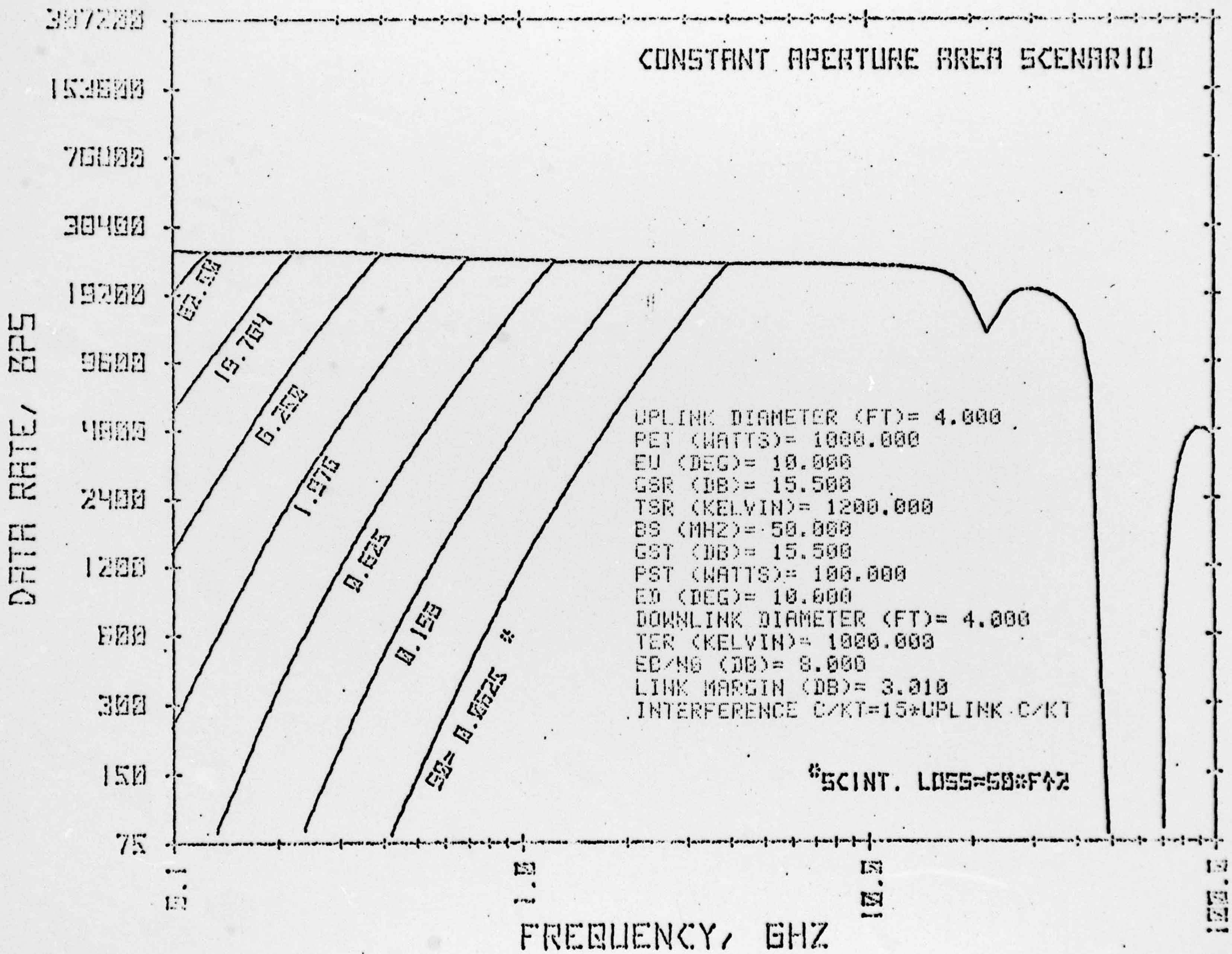

Figure 3. Absorption Loss Through the Atmosphere for Various Elevation Angles